**Before the**
**FEDERAL COMMUNICATIONS COMMISSION**
**Washington, D.C. 20554**

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| In the Matter of | ) | |
| | ) | |
| Update to Parts 2 and 25 Concerning Non-Geostationary, Fixed-Satellite Service Systems and Related Matters | ) | IB Docket No. 16-408 |
| | ) | |

# REPLY COMMENTS OF TELESAT CANADA

**TELESAT CANADA**
Elisabeth Neasmith
Director, Spectrum Management and
Development
1601 Telesat Court
Ottawa, Ontario
Canada, K1B 5P4
(613) 748-0123

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# REPLY COMMENTS OF TELESAT CANADA

Telesat Canada ("Telesat") hereby submits this reply to comments on the Notice of Proposed Rulemaking in the above-captioned proceeding (the "NPRM").[1] Telesat focuses its reply principally on certain key areas as to which the parties' comments reflect widely varied opinions. At the outset, however, Telesat notes that virtually all the parties support harmonizing to some degree the Commission's requirements with International Telecommunications Union ("ITU") regulations.[2]

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[1] Update to Parts 2 and 25 Concerning Non-Geostationary, Fixed-Satellite Service Systems and Related Matters, Notice of Proposed Rulemaking, IB Docket No. 16-408, FCC 16-170 (rel. Dec. 15, 2016) ("NPRM").

[2] *See Comments of LeoSat MA, Inc. ("LeoSat Comments") , IB Docket No. 16-408 (Feb 27, 2017), at first page of Executive Summary (" ("Given the global nature of NGSO constellations, LeoSat particularly endorses the Commission's efforts to harmonize the U.S. rules with international requirements established by the International Telecommunication Union ("ITU") in the areas of interference mitigation, coordination, and priority status."); Comments of Space Norway, IB Docket No. 16-408 (Feb 27, 2017)("Space Norway Comments"), at 3("encourages all harmonization of the Commission's Rules with the [ITU Radio Regulations]"); Comments of EchoStar Satellite Operating Corporation and Hughes Network Systems, LLC IB Docket No. 16-408 (Feb 27, 2017)("EchoStar Comments"), at 3 ("supporting co-primary status to GSO FSS operations in the 18.8-19.3 GHz and 28.6-29.1 GHz bands [because] [d]oing so will provide for globally harmonized spectrum consistent with existing ITU allocations…."); [Comments of Space Exploration Technologies Corp. ("SpaceX") IB Docket No. 16-408 (Feb 27, 2017)("SpaceX Comments"), at 21 ("NGSO FSS systems are inherently international in nature, and thus as a practical matter must already comply with the applicable EPFD limits in the ITU Radio Regulations"); Comments of WorldVu Satellites Limited, d/b/a OneWeb ("OneWeb"), IB Docket No. 16-408 (Feb 27, 2017)("OneWeb Comments")( extensive support throughout comments for harmonizing various Commission rules with ITU regulations); Kepler Communications Inc. Comments ("Kepler Comments"), IB Docket No. 16-408 (Feb 27, 2017), at 2("the call to align the Commission's regulations with those set forth in Article 22 of the ITU Radio Regulations is seen as positive"); Comments of Inmarsat ("Inmarsat Comments"), IB Docket No. 16-408 (Feb 27, 2017), at 1("Because satellite systems are international by nature, global regulatory consistency best serves satellite*

This point is crucial because, as emphasized by Telesat in its Comments, satellite network operators whose systems cover large territorial expanses and serve multiple regions of the world must comply with limits and other rules contained in the ITU Radio Regulations, as well as with the rules of all the many administrations in whose territories they operate. Designing and operating international satellite systems to conform to a wide variety of rules for services to different geographic locations can lead to inefficient satellite design and costly implementation.[3] Accordingly, harmonizing national rules with ITU rules is good practice and should be done absent a compelling reason to do otherwise.

Although there is general support for harmonization, the parties diverge on the extent to which harmonization is appropriate with respect to several key issues. Telesat submits that the public interest will be served by the Commission's adoption of rules that are more closely aligned to ITU regulations and coordination processes in the following areas:

- The Commission should apply ITU priority and ITU coordination to in-line events to both U.S.-licensed operators and non-U.S. licensed operators holding U.S. landing rights.

    •• The very diversity of views as to the appropriate angle presented in the various comments supports Telesat's position that there is no single angle that will adequately define in-line events and prevent interference. Further, it would be practically impossible to implement a regime that would require system operators to identify and share spectrum during in-line events on a real-time basis.

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*operators and their customers. Modifications to the Commission's rules therefore should seek to further align domestic licensing and operational rules with the International Telecommunication Union's ("ITU") Radio Regulations"); Comments of SES S.A. and O3b Limited, ("SES/O3b comments"), IB Docket No. 16-408 (Feb 27, 2017), at 20 (supporting application of ITU EPFD limits, to "promote harmonization in the international operation of NGSO FSS systems"); Comments of Intelsat Licensee LLC ("Intelsat Comments") , IB Docket No. 16-408 (Feb 27, 2017), at 4 ("the FCC generally should avoid domestic satellite licensing rules that are out of sync with the ITU regime because doing so risks creating unintended negative consequences for U.S. licensees").*

[3] *See* Comments of Telesat Canada, IB Docket No. 16-408 (Feb 27, 2017) ("Telesat Comments"), at 4.

••Building on the analysis presented by ViaSat,[4] Telesat demonstrates that, given the present number of satellite systems proposed in this proceeding, even if only a very few were implemented, the net effect of a "share during in-line interference events" regime, very likely would result in the functional equivalent of band segmentation.

••To avoid such a generally-recognized undesirable result and to provide the certainty of access to sufficient usable spectrum that must exist before NGSO satellite operators will spend the enormous sums necessary fully to develop broadband capabilities, the Commission should apply ITU priority and ITU coordination requirements in lieu of any other interference mitigation rule.

•As most parties agree, the Commission should adopt Article 22 EPFD limits to protect GSO FSS from possible interference from NGSO systems. Telesat also agrees with the urging of several parties that the Commission review and relax its proposed EPFD compliance showing requirements as applied to the Ka-band both because they are unnecessarily burdensome and because they are well-beyond ITU showing obligations.

•The Commission should not adopt a cap on earth station uplink EIRP density. Such a cap would unnecessarily reduce the capacity of systems with consequent increased costs to deploy more satellites, which costs would have to be borne by consumers. Instead, such limits as may be required in particular circumstances should be left to be resolved through the ITU coordination process.

In addition, recognizing that the question of what should constitute bringing an NGSO system into use is now also under review by the ITU and given the diversity of system proposals, the Commission should adopt the substantial service standard proposed by Telesat,[5] but with the addition of a "safe harbor" for license retention if at least a third of a proposed constellation is placed in service within six years. Telesat urges that a further showing requirement at nine years is unnecessary, but if imposed, at most it should limit an operator's ability to expand further without additional authorization, but not jeopardize its existing service.

[4] *See* Comments of ViaSat, Inc. ("ViaSat Comments"), IB Docket No. 16-408 (Feb 27, 2017), at 19-21, Exhibits 1 and 2.

[5] See Telesat Comments, at 18.

## I. THE COMMISSION SHOULD APPLY ITU PRIORITY AND ITU COORDINATION REQUIREMENTS IN LIEU OF ANY OTHER IN-LINE EVENT INTERFERENCE MITIGATION RULES

### A. Overview

The premises under which the Commission's rules were first adopted specifying the use of a fixed avoidance angle (10°) to prevent harmful interference between systems have fundamentally changed. The rules do not comport with the reality of current NGSO FSS constellation system design or with the fact that user terminals will be increasingly mobile. As pointed out by SES/O3b: "The current ten-degree separation threshold for co-frequency NGSO FSS space station operations is based on the characteristics of satellite and earth station systems proposed at the beginning of this century. Much innovation has occurred since that time."[6]

Telesat demonstrated in its Comments that neither the 10° angle specified in the Commission's rules - nor any other single angle - would adequately define the avoidance angle required between any two systems in order to avoid harmful interference. In Attachment A to Telesat's Comments, Telesat demonstrated that with a fixed avoidance angle, in this case 10°, the generated interference levels vary by up to 15 dB depending on the system characteristics. This would result in a wide range of "permitted" interference levels all being deemed to meet the Commission's requirements. Conversely, at any specific interference level, a wide variety of angles would be calculated. Not only does the angle vary among different constellations, but between any two constellations the angle will vary based on the relative position of satellites to ground terminals. As discussed below, the divergence of positions expressed in the comments as

[6] SES/O3b Comments, at 25.

to what that angle should be or, as urged by OneWeb, applying an ITU $\Delta T/T$ 6% standard to calculate the separation angle, serves only to strengthen Telesat's point.

As also demonstrated in Telesat's Comments, for an avoidance angle rule to be implemented with the systems proposed today, the operators of each system would have to know the location, details of operation, and intended transmission time of every earth station, including mobiles, and every satellite of every other NGSO constellation system authorized in the same band. After all this information is gathered, the operator then would have to factor in the same level of information about its own network operations, all in real time. To make this work, competing systems, in effect, would need to be interoperable, which would be simply unrealistic to expect or to implement.

Telesat's analysis showed that the degree to which systems would suffer in-line interference from other systems is dependent upon the system design and operation of other systems and will vary by system. Yet, because it cannot be determined in advance which constellations actually will be built, when and in what planes satellites actually will be deployed, when and where earth stations will be made operational, and whether the technical parameters will remain as filed or be modified, it would be impossible for an operator to know when sharing of spectrum between two or more operators would lead to unacceptable levels of interference, in other words when spectrum segmentation would be necessary. As a result, a "share during in-line events" rule fails to provide operators the necessary level of certainty that they will have sufficient useable spectrum to implement their systems and serve their customers. That lack of certainty will thwart those otherwise willing to make the enormous investment necessary to provide broadband services to a wide variety of users and to bridge the digital divide and to meet the requirements of government users. To make such investment, operators must have confidence that their access to spectrum will not be jeopardized as new systems are launched and that, throughout the life of their systems, they will be protected from harmful interference.

Finally, Telesat demonstrated that the so-called default mechanism of band sharing would have to be employed so often as to create the functional equivalent of band segmentation. ViaSat's analysis of in line events between only its NGSO system and of Boeing's proposed system supports Telesat's position. That analysis uses simple assumptions but shows in line events occurring 46.7% of the time.[7] At Exhibit 1 hereto, Telesat advances this work by providing the results of a more comprehensive simulation that takes into account the stated characteristics of the ViaSat and Boeing systems and that expands the analysis to take into account the impact upon ViaSat when a third constellation, OneWeb, is added to the equation. That analysis shows that Viasat would experience interference 85.8% of the time when both the Boeing and OneWeb constellations are considered.

As pointed out in Telesat's Comments, there is an effective alternative to avoiding inter-system interference: namely, the coordination, based on ITU priority, that already is required under ITU rules.[8] Application of the ITU rules is essential to provide systems the necessary certainty as to the availability of spectrum free from harmful interference.

### B. No Single Avoidance Angle Will Address In-line Interference Events

Telesat demonstrated in its Comments that there is no "one-size-fits-all" angle for determining in-line interference events. Defining a default avoidance angle, whether 10° or some other single value, is not workable because the in-line event interference is a function of the unique design parameters of the constellations and, as a result, the angles vary widely on both

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[7] *See* ViaSat Comments, at 19-20 and Exhibit 1.

[8] See Telesat Comments, at 14-15.

the uplink and downlink. Thus a single avoidance angle will result in different systems causing widely varying amounts of interference to other systems. Further, because a chief driving factor in interference causation is the characteristics of the interfering system, the application of a single angle value would allow some systems to cause more interference than others at the avoidance angle. Furthermore, transmissions made outside the avoidance angle specified by the Commission could cause harmful interference yet be permitted without sanction and the offending operator would have no incentive to design their systems in order to avoid such result.

The parties' disagreements as to the appropriate angle for the Commission to employ validate Telesat's position that no single angle can suffice. There is little support for the current 10° default angle—SpaceX being the lone commenting party to support maintaining this standard--and even its support appears qualified.[9] SES/O3b suggest that a smaller angle might be more appropriate, but offer no suggestion as to what that angle that might be.[10] Boeing implicitly recognizes that no single angle works for all circumstances. It suggests separate rulemaking proceedings, by band, whereby through the use of some form of unstated analysis of the applications presented, a band-specific angle might be developed.[11] Kepler too opposes the 10° trigger angle, suggesting that "smaller angles of separation can and should be negotiated during coordination between the parties."[12]

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[9] See SpaceX Comments, at 19-21.

[10] See SES/O3B Comments, at 25.

[11] *See* Boeing Comments, at 13.

[12] *See* Kepler Comments, at 4.

LeoSat is the lone commentator to offer a specific recommendation for an alternative trigger for determining in-line interference events: it says the angle should be "reduced preferably to 2º, and to no more than 3º."[13] But LeoSat, like other commenting parties suggesting some unspecified smaller angle, offers no technical analysis to justify such a narrow range. At bottom, the issue of prime concern should be *the interference caused by one system (or multiple systems) to another*. Yet, as to that issue, the angle of separation between the systems does not come close to resembling an accurate defining factor.

As demonstrated in the attached Exhibit 2, the avoidance angle required to ensure a specified level of interference between two systems is not exceeded depends on the characteristics of those two systems, with the primary driving factors being the characteristics of the interfering satellite. Moreover, this angle further depends on the relative position of the satellites to the relevant earth station. Based upon a sample interference criterion, the analysis in Exhibit 2 shows the minimum and maximum avoidance angles required to protect any system from a specified other system. As the satellites move, the actual angle required to avoid in-line events will vary between the minimum and the maximum. Hence, a fixed avoidance angle, even between two specified systems, will in some cases not protect from interference, and in other cases will over-protect, requiring spectrum sharing for a longer duration than necessary to avoid interference.

Telesat agrees with SpaceX's Comments that, taking into account the characteristics of many systems that are proposed, a "separation angle trigger at a reduced level [below 10°]…would effectively compromise direct-to-consumer satellite broadband offerings from

[13] See LeoSat Comments, at 12.

NGSO FSS systems."[14] But, as shown in Exhibit 2, even at 10°, interference can be expected to occur from many systems, particularly those operating at higher elevations and power.

Recognizing that no single angle can be used to define interference, OneWeb suggested to replace the 10° trigger by the ITU ΔT/T 6% standard.[15] Putting aside the particular interference level OneWeb suggests to be employed, the practical problems associated with trying to implement OneWeb's proposed standard are insurmountable.

In order to calculate the ΔT/T parameter:

• Interference to both uplinks and downlinks must be determined, therefore the interfering operator must know, for each potentially affected earth terminal:

•• the type of terminal to which it may cause interference;

•• that terminal's thermal noise;

•• the location of that terminal.

•The operator must then:

•• perform the calculation based on the interfering system's EIRP density to determine the downlink component; and

•• determine the uplink component with knowledge of each of the other NGSO satellite G/T and terminal EIRP density.

• All these calculations would have to be performed in real time until the 6% is reached, which would trigger the in-line event sharing requirement.

• Some of this information may not be available, *i*.e., the location of ubiquitously deployed and mobile user terminals.

• Even to the extent that such information could be provided, requiring systems to share and update continuously such commercially sensitive information with competitors raises potentially serious competitive concerns.

[14] SpaceX Comments, at 21.

[15] See OneWeb Comments, at 14-15.

The $\Delta T/T$ method is an acceptable tool for static configurations such as GSOs, where there are minimum changes in position and only adjacent systems with which to coordinate. In the case of NGSO, where satellites are constantly moving and terminals (some of which may be mobile) will be added on a regular basis, this method simply would be impractical to implement.

### C. A "Share during In-Line Events" Regime Will Likely Result in the Functional Equivalent of Band Segmentation

In its Comments, Telesat raised the concern that, if in-line events occur a substantial amount of the time and the Commission mandates frequency sharing during in-line events, then the Commission would be establishing a regime that is functionally equivalent to band segmentation.[16] Such a result would leave every system with insufficient bandwidth, which would undercut the Commission's goal of facilitating a viable broadband service.

That danger is reflected in ViaSat's Comments which reference its rough analysis estimating that in-line events (applying a 10° angular separation standard) would occur to its V-band constellation 46.7 percent of the time once Boeing's network is fully implemented.[17] Building on that analysis, as shown in Exhibit 1, Telesat presents a more refined analysis, using an industry-standard simulation software,[18] to simulate and thus more accurately model the impact of the Boeing constellation on the Viasat constellation. Telesat also expanded the analysis to include a third constellation, OneWeb, to illustrate the impact on Viasat of both Boeing and OneWeb. The Telesat simulation shows in-line events (calculated using a 10° angle)

[16] See Telesat Comments, at 14.

[17] See ViaSat's Comments at 19-20, note 40. We note that, as long as in-line events are defined by angle of separation, the frequency band, as long as a single one is used, would have no impact on the calculation of number of in-line events.

[18] Systems Tool Kit (STK) software available from Analytical Graphics, Inc. (AGI) www.agi.com

vary considerably by latitude, but would occur on average 63.5% of the time when interference from only Boeing to Viasat is considered, as compared to the 46.7% value calculated by Viasat using simplified assumptions. Furthermore, the Telesat analysis shows that on average Viasat would experience interference 85.8% of the time when interference from both the Boeing and OneWeb constellations is considered.

With so many in-line events, the operative assumption underlying the Commission's "share during in-line events" regime that "in-line interference events will occur in a small number of the annual operating hours" is no longer valid. Rather than an occasional adjustment to address such events, absent application of ITU priority and coordination requirements, in line events would occur so often that the *de facto* result would be band segmentation.

### D. The Commission Should Apply ITU Priority and Coordination Requirements to Sharing among NGSO FSS Systems

As discussed in Telesat's Comments, the ITU already has regulations in place that govern sharing, based on priority, and coordination, among NGSO FSS systems in the Ku-band and the Ka-band. These regulations already apply to sharing between systems licensed by more than one administration. ITU priority rules provide operators with the necessary certainty as to the amount of useable spectrum that they will have available for their systems. That certainty is essential for those prepared to make the substantial investment that will be required to implement an NGSO FSS system of the scope required effectively to serve U.S. and worldwide broadband requirements. Accordingly, for the reasons stated herein and in Telesat's Comments,[19] Telesat urges the Commission to condition both U.S. NGSO FSS licenses and non-U.S. landing rights

[19] See Telesat Comments, at 6-15 and Attachment A thereto.

authorizations on priority-based inter-system coordination in accordance with these ITU regulations.

LeoSat, the one party in addition to Telesat to propose the application of ITU priority to in-line event interference, urges that NGSO FSS operators be required to follow the relative priority of ITU filings in situations of in-line interference.[20] LeoSat, like Telesat, recognizes that "If the Commission implements a coordination process that is also utilized internationally, NGSO FSS operators will have increased certainty about their operations and their obligations to address interference."[21] Telesat notes, moreover, that while not addressed in their comments in this proceeding, other Ka-band applicants have recognized the need to coordinate their systems in accordance with ITU priority.[22]

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[20] *See* LeoSat Comments, at 12.

[21] *Id.* at 13. As discussed above, Telesat does support LeoSat's suggestion that such priority be limited to in-line events from within a two or three degree angle.

[22] For example, OneWeb acknowledges that the ITU's rules require that systems with lower priority coordinate their operations with systems that have date priority: "According to ITU procedures (RR 9.12), for all of the Ku-band and Ka-band frequency ranges to be used by OneWeb, coordination amongst NGSO systems is on a first-come, first-served basis, depending on the ITU date priority of the relevant ITU filings."[22] See *WorldVu Satellites Limited, Petition for a Declaratory Ruling Granting Access to the U.S. Market for the OneWeb System*, IBFS File No. SAT-LOI-20160428-00041, Technical Narrative at 35 (filed April 28, 2016). Similarly, O3b acknowledges in its Petition for Declaratory Ruling that, "[a]ccording to ITU procedures (No. 9.12), for all of the Ka-band frequency ranges to be used by O3b, coordination among NGSO systems is based on a first-come, first-served basis, depending on the ITU date priority of the relevant ITU filings. "See *O3b Limited, Amendment to Application to Modify U.S. Market Access Grant for the O3b Medium Earth Orbit Satellite System*, IBFS File No. SAT-AMD-20161115-0016, Technical Narrative at 20 (filed November 15, 2016).

## II. ARTICLE 22 EPFD LIMITS SHOULD BE ADOPTED BY THE COMMISSION TO PROTECT GSO FSS FROM POSSIBLE INTERFERENCE FROM NGSO SYSTEMS

There is general support for the Commission's proposal to adopt Article 22 EPFD limits for the protection of GSO FSS from possible interference from NGSO systems.[23] SpaceX notes, among other factors, that because these limits already apply internationally, applying these limits in the United States "has the added benefit of enabling global NGSO systems to implement a common strategy for system design and operation in all areas of the world."[24] Lockheed Martin points out this and related proposals "would codify existing practices and thus provide greater regulatory certainty on matters already deemed consistent with the public interest."[25]

Telesat concurs with these views. As a longstanding GSO operator, Telesat is keenly aware of the balances of the issue on both sides of the table and urges the Commission to adopt the ITU EPFD limits.

Telesat, however, disagrees with ViaSat's claim that a reexamination of the application of existing ITU EPFD limits for the protection of GSO FSS systems is required. [26] Those limits were years in the making. ViaSat's parade of horribles is entirely speculative and does not form a sufficient basis for arguing that these limits be revisited, and certainly not on an individual national level rather than in the international ITU forums.

[23] *See, e.g.*, SpaceX Comments, at 21-22; LeoSat Comments, at 9; Lockheed Martin Comments at 2; OneWeb Comments, at 3.

[24] SpaceX Comments, at 22.

[25] Lockheed Martin Comments, at 2.

[26] *See* ViaSat Comments, at 11-12.

Telesat notes, moreover, that while ViaSat claims the ITU EPFD limits may need to be strengthened to account for interference from currently designed systems, several aspects of many of those systems' designs suggest that their interference potential may be less, not more, than prior systems. Thus, features such as steerable spot beams, radio resource management (RRM) systems, satellites transmitting only when traffic is present, and ground terminals that transmit only when a downlink is present, all will tend to reduce the overall EPFD. Changes in GSO system design, including narrower beams, may also make them less susceptible to interference. ViaSat itself recently published a report citing several design features that make its GSO satellites more resilient to potential interference sources.[27]

As noted above, Telesat, as a GSO operator, is also concerned with possible interference from the deployment of new NGSO constellations at Ku-/Ka-/and V-band. As a worst-case analysis to see the impact on GSO in the Ka-band, Telesat performed an interference analysis to evaluate the impact of an NGSO network on a GSO network when the NGSO operates at the maximum level consistent with the more lenient compliance standard that is set forth in ITU Article 22, Table 22-1B.[28] Results showed that the added interference to the GSO, due to the NGSO operating at an EIRP level such that the NGSO was complying with Table 22-1B, was within levels acceptable to the GSO.

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[27] *See* ViaSat article at https://www.viasat.com/news/reinventing-space-part-3-satisfying-concerns-about-commercial-hts-availability-anti-jam.

[28] Article 22 of the ITU RR provide epfd levels for Ku-band and segments of the Ka-band. If the NGSO does not exceed the relevant epfd limit, coordination is not required with the GSO. In the Ka-band there is one set of limits for the 17.8-18.6 GHz band (Table 22-1B) and one set of limits for the 19.7-20.2 GHz band (Table 22-1C). The limits in Table 22-1B are 12 dB higher (*i.e.*, less restrictive on the NGSO) than those in Table 22-1C.

With respect to demonstration of compliance with EFPD limits, Telesat agrees with the views of OneWeb and Boeing asking that the Commission review and relax proposed rules regarding the showings that Ka-band systems must make to demonstrate their compliance with ITU EPFD limits.[29]

As pointed out by Boeing, the circumstances under which the rules in question were first created for Ku-band systems are unlike Ka-band circumstances and several of the requirements are unnecessarily burdensome for Ka-band systems. Instead, Boeing recommends an industry task force review the question of what compliance showing, if any, should be required.[30]

Similarly, OneWeb argues that the requirement for an EPFD compliance showing 90 days before a system's launch of its first satellite is overly burdensome and should be eliminated. OneWeb notes that this requirement goes well beyond anything required by the ITU and that, at most, "the Commission should only require such a showing in cases where a GSO FSS earth station actually experiences excess (operational and additional operational) EPFD as compared to the limits currently set forth in §25.208(b)."[31]

## III. THE COMMISSION SHOULD NOT ADOPT A CAP ON EARTH STATION UPLINK EIRP DENSITY.

As Telesat pointed out in its Comments, EIRP density limits for NGSO/FSS uplink transmissions are unnecessary as long as Article 22 EPFD limits and ITU coordination

[29] *See* OneWeb Comments, at 25-27; Boeing Comments, at 9-10.

[30] *See* Boeing Comments, at 10.

[31] OneWeb Comments, at 27.

requirements are observed.[32] OneWeb takes a similar view that inter-operator coordination should be relied upon in lieu of any such restrictions.[33]

Boeing raises concerns about the effects of EIRP density limits on "low-cost broadband access," arguing that "fixed limits at this time could easily impair growth and innovation" in broadband services.[34] Telesat shares Boeing's concerns, principally because imposing EIRP density limits would reduce broadband capacity which would adversely affect the availability of consumer services. This capacity deficit might be reduced by deploying more satellites, but doing so would increase system costs, which would lead to higher prices for consumers. Further, rather than facilitating sharing among constellation systems, as suggested by some of the parties,[35] having to increase numbers of satellites could have the reverse effect of creating more events of in-line interference.

Another major problem with establishing a broad brush EIRP density limit on NGSO/FSS uplink transmissions is that such limits would be both overly restrictive on the operation of systems in some instances while insufficient to protect against interference in other instances. Just as in the case of angular separation, a one-size-fits-all EIRP density limit will be both under- and over-inclusive as to the limits that must be observed by particular systems to avoid interference. Rather, in order properly to take into account the variety of constellation

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[32] *See* Telesat Comments, at 17.

[33] *See* OneWeb Comments, at 28.

[34] *See* Boeing Comments, at 16.

[35] *See, e.g.,* Lockheed Martin Comments at 4.

systems and ground networks, coordination among systems under ITU processes will lead to a more efficient result.

## IV. MILESTONE RULES SHOULD BE FLEXIBLE ENOUGH TO REFLECT THE DIVERSITY OF SYSTEM PROPOSALS.

Perhaps to be expected by the diversity of system proposals before the Commission, the comments also reflect a wide diversity of suggested milestone requirements. At one end of the spectrum, Space Norway suggests a milestone requirement of 10 to 20 percent of proposed satellites in service at the six-year mark.[36] At the other end, Kepler suggests a 75% standard[37] and OneWeb suggests 100%, but, significantly, would make the penalty a loss of bond, not a loss of license for the satellites already launched.[38] Others, like Telesat,[39] suggest more flexible standards as sufficient to meet a "substantial service" business case test.[40] Lockheed Martin suggests a 50-75% test,[41] but would also allow applicants to meet a lesser percentage upon a showing that they are providing "a meaningful quality of service".[42]

Taking into account the various proposals, Telesat suggests that a hybrid model that would allow operators some level of certainty as to the minimum standard of implementation necessary to preserve their authorizations while at the same time allowing systems necessary

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[36] *See* Space Norway Comments, at 14.

[37] *See* Kepler Comments, at 5.

[38] *See* OneWeb Comments, at 2-3.

[39] *See* Telesat Comments, at 18.

[40] *See* SpaceX Comments, at 15; Boeing Comments, at 17.

[41] *See* Lockheed Martin Comments, at 7.

[42] *Id.* at 6.

flexibility in system implementation. That hybrid model would give operators the option either to make a sufficient showing of substantial service or meet a minimum “safe harbor” standard, which Telesat suggests to be set at 33% at the six-year mark.[43]

Telesat urges that an additional showing at the nine-year mark is not needed; certainly not if a substantial service showing has been made at year six. If and to the extent the Commission determines that such an additional showing requirement should be imposed, however, Telesat urges that the sanction for not meeting the nine-year standard should be limited to curtailing system expansion without additional authorization. Systems having met the six-year showing requirement should not be at risk of loss of license for that part of their system already placed in service, nor should their customers be at risk of loss of service.

## V. CONCLUSION

The parties’ comments in this proceeding reinforce the positions and conclusions reflected in Telesat’s Comments in two respects: first, when there is general agreement on certain points, such as the merit of harmonizing relevant FCC rules with those of the ITU, and second, when the parties’ various positions highlight the impracticalities of selecting a single standard for identifying and resolving in-line interference events. Accordingly:

- The Commission should reject proposals for sharing during in-line events that
    - Are based on the characteristics of early-generation systems and do not take into account the large constellation sizes and designs that are representative of today’s systems and the fact that many users of the next generation systems will be mobile.

[43] Precedent for such an alternative showing requirement can be found in the Commission’s PCS rules. *See* 47 C.F.R. § 24.103.

- Are premised on there being a single, fixed angle for in-line events, when in fact the angle needed to protect systems will vary widely and be determined by the particular technical and operating characteristics of each system.

- Are unworkable commercially and technically, because the requirements for implementing a regime based on in-line events would be so complex as to be infeasible and would require operators, in effect, to make their systems interoperable.

- Would be the functional equivalent of band segmentation, because even if only a portion of the proposed constellations actually are deployed, in-line events would occur so often and trigger band sharing almost continuously, which virtually everyone agrees would be bad policy.

- Would create uncertainty as to the useable spectrum available to an operator and would, therefore, discourage investment in the very broadband systems most likely to advance important public interests.

- Rather, the Commission should:

  - In lieu of any other in-line event interference mitigation rules, apply well-established and generally-accepted ITU priority and coordination requirements to sharing among all NGSO FSS systems whether they are licensed by the Commission or hold U.S. landing rights.

  - Adopt ITU Article 22 EPFD limits to protect GSO FSS from possible interference from NGSO systems and review and relax the showings that Ka-band systems must make to demonstrate their compliance with ITU EPFD limits.

  - Adopt a hybrid model for demonstrating compliance with milestone requirements which would give operators the option either to make a sufficient showing of substantial service at the six-year mark or meet a minimum "safe harbor" standard of deployment of 33% of their proposed constellation at that mark. An additional showing at the nine-year mark is not needed.

  - Not adopt a cap on earth station uplink EIRP density, but rather adopt its proposals that would provide for greater flexibility in NGSO FSS operations and facilitate system implementation and management, as outlined in Telesat's Comments.

  - Make the changes addressed in Telesat's Comments that would foster operational flexibility and spectrum efficiency.

Respectfully submitted,

TELESAT CANADA

/s/ ____________________
Elisabeth Neasmith
Director, Spectrum Management and Development
1601 Telesat Court
Ottawa, Ontario
Canada, K1B 5P4
(613) 748-0123

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EXHIBIT 1

This Exhibit expands upon an analysis provided by ViaSat in its Comments to the Boeing V-band Petition for Declaratory ruling.[1] In that showing Viasat provided an analysis to estimate the probability of an in-line interference event from the Boeing 2,956 satellite LEO constellation to the Viasat 24 satellite MEO constellation. The ViaSat analysis made the simplifying assumptions that (i) the Boeing satellites are uniformly distributed over the spherical shell at their orbital altitude; and (ii) the relevant VIASAT-NGSO satellite is directly above the earth station with which it is communicating, at a 90° elevation angle. An in-line event was deemed to have occurred when one Boeing satellite was within the 10° avoidance angle specified in Section 25.261. With these assumptions, the ViaSat analysis estimated in-line events would occur 46.7% of the time once Boeing's network is fully implemented.

Telesat expanded on the ViaSat analysis by using an industry-standard simulation software[2] to simulate and thus more accurately model the impact of the Boeing constellation on the ViaSat constellation. Telesat also expanded the analysis to include a third constellation, OneWeb, to illustrate the impact of Boeing and OneWeb on ViaSat. For the Telesat analysis, in lieu of the simplifying assumption (i) noted above, the parameters for the ViaSat and Boeing constellations as filed with the FCC[3] and summarized in Table 1-1 were used, and in lieu of

[1] *In re IBFS File No. SAT-LOA-20160622-00058*, Comments of ViaSat, Inc., at 3 and Exhibit A (December 1, 2016).

[2] Systems Tool Kit (STK) software available from Analytical Graphics, Inc. (AGI) www.agi.com

[3] *See, ViaSat, Inc., Petition for Declaratory Ruling Granting Access to the U.S. for a Non-U.S.-Licensed Nongeostationary Orbit Satellite Network*, IBFS File No. SAT-LOI-20161115-00120 (Nov. 15, 2016); and *The Boeing Company, Amendment to Application for Authority to Launch and Operate a Non-Geostationary Low Earth Orbit Satellite System in the Fixed Satellite Service,* (IBFS File No. SAT-AMD-20170301-00030 (Mar. 1, 2017).

simplifying assumption (ii) noted above, satellites at all elevation angles were considered. Again, an in-line event was deemed to have occurred when one Boeing satellite was within the 10° avoidance angle specified in Section 25.261.

The results of the Telesat analysis are provided in Table 1-2. Note the number of in-line events varies by latitude, therefore, for analysis purposes, ground locations were selected at increments of 5° latitude. Table 1-2 shows, for each latitude, the total seconds and percentage per day of in-line events, for the case of Boeing interference to ViaSat, and Boeing and OneWeb interference to ViaSat. As expected, more in-line events occur near the pole. The Telesat simulation shows in-line events would occur on average 63.5% of the time when interference from only Boeing to ViaSat is considered, as compared to the 46.7% value calculated by ViaSat using simplified assumptions. Furthermore, the Telesat analysis shows that on average ViaSat would experience interference 85.8% of the time when both the Boeing and OneWeb interfering constellations are considered.

### Table 1-1 Parameters for Telesat Analysis of In-Line Event

| ADM | OPERATOR | SAT_NAME | Orbit type | Number of orbital planes | Number of satellites per orbit | Total Number of satellites | Minimum Elevation angle (deg) | Inclination | Apogee [km] | Perigee km] |
|---|---|---|---|---|---|---|---|---|---|---|
| HOL | VIASAT | VIASAT-NGSO | MEO | 3 | 8 | 24 | 25 | 87 | 8200 | 8200 |
| USA | BOEING | USASAT-NGSO-1B | LEO | 35 | 32 | 1120 | 45 | 45 | 1200 | 1200 |
| | | | | 6 | 46 | 276 | | 55 | | |
| | | | | 12 | 46 | 552 | | 55 | | |
| | | | | 21 | 48 | 1008 | | 88 | 1000 | 1000 |
| | | | Total | | | 2956 | | | | |
| G | ONEWEB | L5 | LEO | 18 | 40 | 720 | 15 | 87.9 | 1200 | 1200 |

### Table 1-2
### In-Line Event Simulation Results
### Interference to Viasat from Boeing, and to ViaSat from Boeing and OneWeb

| Ground Coordinate | | Impact on Viasat due to Boeing | | Impact on Viasat due to Boeing and OneWeb | |
|---|---|---|---|---|---|
| Lat (°N) | Long | Total seconds of inline event / day | % of time per day | Total seconds of inline event / day | % of time per day |
| 90 | 0 | 86164 | 99.7% | 86164 | 99.7% |
| 85 | 0 | 85950 | 99.5% | 86164 | 99.7% |
| 80 | 0 | 82713 | 95.7% | 86164 | 99.7% |
| 75 | 0 | 76298 | 88.3% | 86073 | 99.6% |
| 70 | 0 | 68869 | 79.7% | 85939 | 99.5% |
| 65 | 0 | 55789 | 64.6% | 85606 | 99.1% |
| 60 | 0 | 48405 | 56.0% | 85332 | 98.8% |
| 55 | 0 | 53938 | 62.4% | 84981 | 98.4% |
| 50 | 0 | 63495 | 73.5% | 83565 | 96.7% |
| 45 | 0 | 61330 | 71.0% | 81083 | 93.8% |
| 40 | 0 | 62943 | 72.9% | 79302 | 91.8% |
| 35 | 0 | 50079 | 58.0% | 70881 | 82.0% |
| 30 | 0 | 42049 | 48.7% | 66383 | 76.8% |
| 25 | 0 | 38200 | 44.2% | 61501 | 71.2% |
| 20 | 0 | 36883 | 42.7% | 59211 | 68.5% |
| 15 | 0 | 33300 | 38.5% | 56362 | 65.2% |
| 10 | 0 | 33058 | 38.3% | 55897 | 64.7% |
| 5 | 0 | 32051 | 37.1% | 54582 | 63.2% |
| 0 | 0 | 31398 | 36.3% | 53923 | 62.4% |
| Average | | 54890 | **63.5%** | 74164 | **85.8%** |

EXHIBIT 2

This Exhibit demonstrates the wide range of avoidance angles that are calculated for various systems, when a fixed sample interference tolerance or trigger is considered. For illustrative purposes Telesat uses as a sample interference trigger the value -161.4 dBW $m^2$/MHz, which is the downlink epfd limit of ITU RR Article 22, Table 22-1B, for an earth station of 1m diameter.

Using this sample fixed interference trigger of -161.4 dBW $m^2$/MHz, as illustrated in Figures 2-1 and 2-2 below, the avoidance angle is bounded between the two extremes: (i) the maximum avoidance angle, which occurs when the satellites from the two constellations are approximately directly above the interfered-with earth station so that the slant range is the same as satellite altitude, and (ii) the minimum avoidance angle, which occurs when the satellites are at the maximum slant range (calculated based on reported minimum elevation angle for the service).

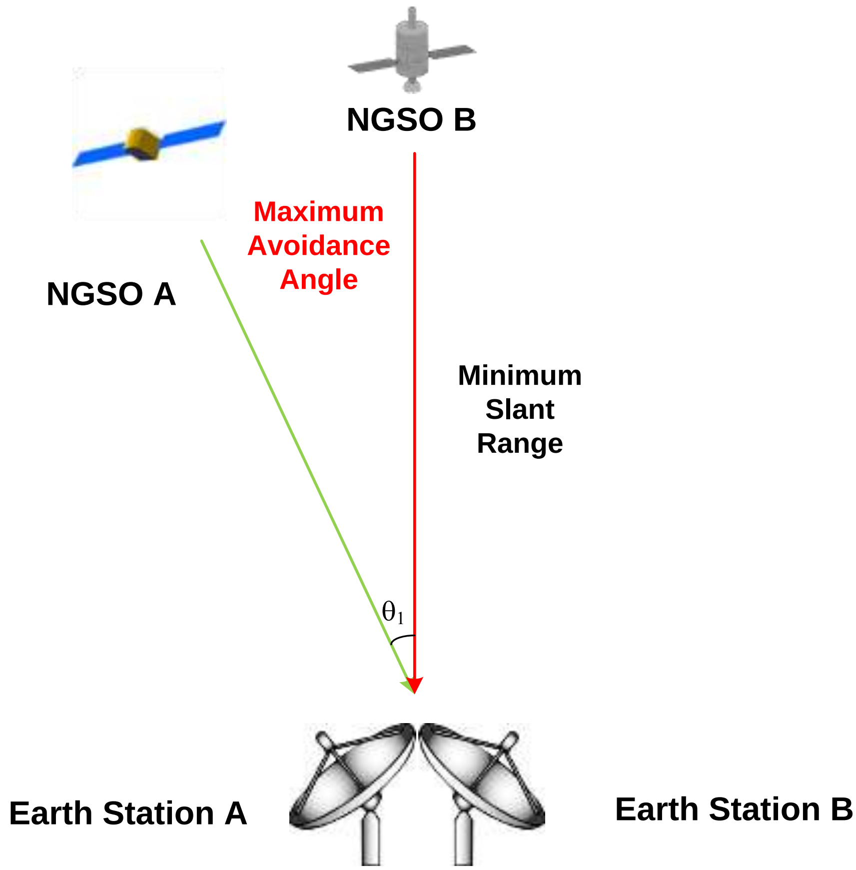


Figure 2-1 Maximum Avoidance Angle ($\theta_1$) Geometry

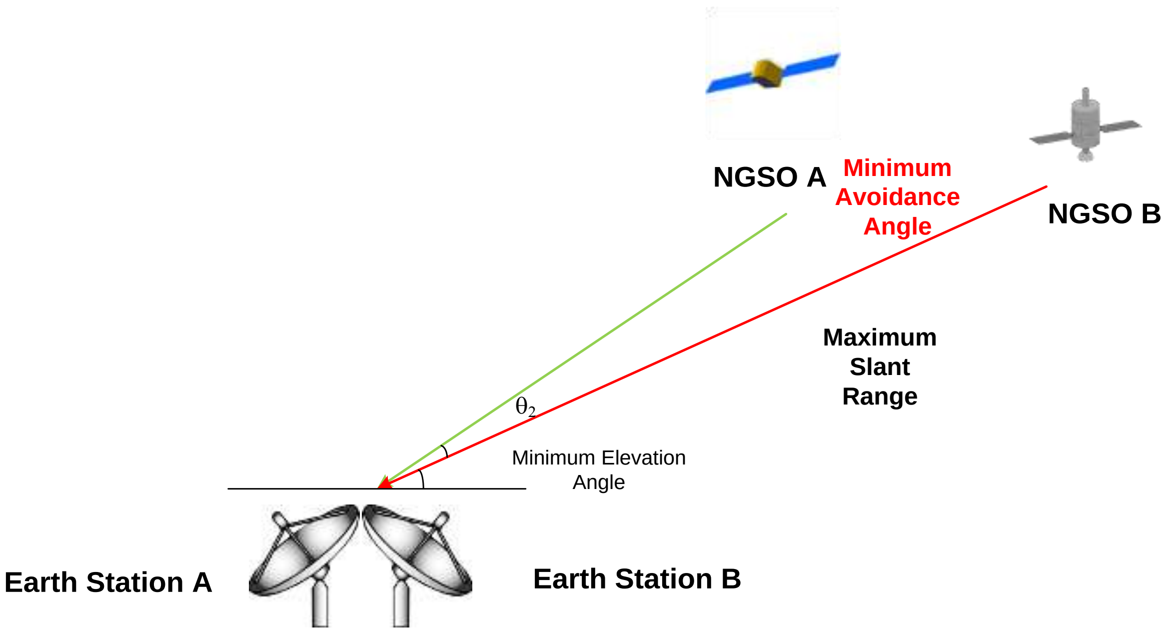


Figure 2-2 Minimum Avoidance Angle ($\theta_2$) Geometry

The results in Table 2-1 show that with a fixed sample interference trigger to avoid in-line interference, a wide range of avoidance angles is calculated. If a different fixed sample interference trigger were selected, the avoidance angles would change. But whatever interference value might be employed, there would remain a wide range of avoidance angles dependent on the characteristics of the two systems considered. Furthermore the avoidance angles will vary as a function of the particular satellite and earth station location of either the interfering or the victim system.

**Table 2-1**
**Minimum and Maximum Avoidance Angles To Protect an Earth Station Belonging to one Constellation, from another (Interfering) Constellation, for a Sample Interference Criterion**

| (Interfering) Constellation[1] | Minimum Slant Range ($d_1$) | Minimum Elevation Angle | Maximum Slant Range ($d_2$) | Maximum EIRP Density | Sample Interference Criterion | Maximum Avoidance Angle ($\theta_1$) (angle associated with $d_1$) | Minimum Avoidance Angle ($\theta_2$) (angle associated with $d_2$) |
|---|---|---|---|---|---|---|---|
| | km | deg | km | dBW/MHz | dBW $m^2$/MHz | deg | deg |
| LeoSat | 1400 | 10 | 3400 | 15.0 | -161.4 | 13.6 | 6.7 |
| O3B | 8062 | 5 | 12400 | 37.5 | -161.4 | 26.6 | 18.8 |
| OneWeb | 1200 | 15 | 2700 | 8.0 | -161.4 | 8.1 | 4.2 |
| Telesat | 1000 | 10 | 2700 | 10.0 | -161.4 | 11.2 | 5.1 |
| Telesat | 1248 | 20 | 2534 | 10.0 | -161.4 | 9.4 | 5.3 |
| SpaceX | 1150 | 40 | 1600 | 15.6 | -161.4 | 16.8 | 12.9 |
| ViaSat | 8200 | 25 | 10600 | 36.0 | -161.4 | 22.8 | 18.6 |

[1] Parameters taken from relevant PDR